

# FOUNDING EVALUATION INDICATORS AND SCALES OF CREATIVITY AND AESTHETICS OF INTERIOR DESIGN WORKS BY APPLYING FUZZY-LOGIC SYSTEM

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## ABSTRACT

*In the profession of interior design, in addition to satisfying the basic needs for function, creativity and aesthetics are two key factors which influence the additional values and preference of a work. But what are creativity and aesthetics? What qualities or characters of a design work should possess in order to be regarded as creative and aesthetic? These are key issues but have not been explored systematically. The advanced progress of artificial intelligent such as Fuzzy-Logic in the recent decades provides further possibilities and breaking through for the scientific research on those sensational concepts such as creativity and aesthetics which are fuzzy, vague and beyond observation. By applying Fuzzy method, questionnaire and experts meeting, this research is aimed to analyze constructional components and their images and characters of creativity and aesthetics of interior design works based on the data collected from 948 samples. The result of this research will be used as the basic foundation for further exploration of drawing up evaluation indicators and scales of creativity and aesthetics of interior design works.*

**KEYWORDS:** Creativity, Aesthetics, Interior Design, Fuzzy Logic

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## INTRODUCTION

### Foreword

In the interior design profession, other than satisfying the basic needs of life functions, creativity and aesthetics are two key factors that decide a product's added value and whether the product is likeable. But what are creativity and aesthetics? What qualities or characters of a design work should possess in order to be regarded as creative and aesthetic? These are major issues but have not been explored systematically. Most designers could only interpret or render creativity and aesthetics according to their own experiences.

The composing elements and combinations of interior space is extremely diverse and complex, so how to use certain elements or features in order to present a design work's creativity and aesthetics is an important lesson that every interior designer has to face all the time. However, creativity and aesthetics are complicated cognitive psychological concepts and cannot actually be detected. In academic research, the researchers can test them through valid evaluation and analysis, in order to accurately grasp their context. But, assessment tools for space design's creativity or aesthetics are not being developed. Moreover, they belong to different area of profession, and they are independent from each other and don't mix together.

In terms of design, creativity and aesthetics are inseparable and difficult to clearly distinguish. Creativity contains aesthetic ingredients and aesthetics contains ideas of beauty in the ingredients. Vernon (1979) in the definition of creativity / creative, aesthetics is also included, while in Westberg's (1991) study, the creativity assessment factors also contain aesthetics. Therefore, it is necessary to explore creativity and aesthetics together.

For perceptual concept such as blurry, hard to quantify, and difficult to actual observe, like creativity or aesthetics, it had been lack of effective exploratory tools before. Due to the advanced progress of artificial intelligent, some breakthrough and improvement are surging. Moreover, because fuzzy logic technology could accept and deal with some uncertainty, imprecise, or even just the nature of the information; therefore, it has been quite successful utilized in investment decisions, information processing, image processing, automatic control, and so on. Since assessment for interior design work, the general public always use the words such as very creative, not new, quite beautiful, very nice, or even "I cannot say", and the like, to express their perception. Those comments cannot help designers to accurately grasp and follow. And fuzzy logic is an analysis technique developed to solve such problems and difficulties. Therefore, this study attempts to use fuzzy logic technology to analyze creative / aesthetic interior design work's composing factors, psychological attributes, and visual features. So we could master creative and aesthetic interior design work's composing factors and measured data, for the interior design professional teaching, assessment, and design of reference.

## RELATED LITERATURE REVIEW

### • Creative Assessment

Guilford (1967) summarized the performing characteristics of creativity into "smooth, flexible, unique, and advanced"; Sternberg & Lubart (1999: 3) considered creativity "is a production of both new (novel, such as original or unexpected) and appropriate (i.e. useful or be able to adjust to work limitation) abilities of the product "; Westberg (1991) proposed, creativity contains originality, excellent technique, as well as aesthetic perception. To conclude the views of the above, we can say creativity/ creative performing characteristics shall contain at least: (1) novel (original, unique, innovative ideas), (2) with aesthetic value (pleasing, smooth, sophisticated) and (3) appropriate (practical, flexible, and in line with cultural perception).

Creative assessment for "output of created results" product/ design work has been developed limited assessment methods and tools. According to the point of view of information processing theory, for the assessment of creative design work, such as interior design, because of its nature is clearly belong to the category of "output" messages assessment, so the assessment tools and indicators can be based on the characteristics of this type of work to do matching assessment (allow subjects to grade depend on their own subjective definition of what "creativity" should be). For a specific area of expertise, since it "involves a variety of different skills, different types of knowledge, and an important professional training period" (Gardner, 1993), therefore, their professional creativity should be built on a complete professional knowledge and training. And their creativity index also must have its uniqueness that is different from other professions. For the professional field of interior design, the assessment index of creative degree of the work must be closely related to its professional characteristics, knowledge, and skills involved. And by establishing these indicators, not only students in this professional field will be able to learn more effectively, practitioners in design industry could have more concrete reference standard to follow.

- **Aesthetic Evaluation**

Aesthetic evaluation refers to a person's degree of perceptual measure about beauty of certain things. Empirical researches on the aesthetic degree of physical characteristics of some particular environments are measured and analyzed depended on photograph or pictures as the measurement tools. That is to say, this type of aesthetic assessment is using how the physical characteristics of the environment "pleasing our eyes" as a benchmark. The results of such studies are fairly consistent display that significant perceptual differences exist between architects or other professional designers and the general public. For example, Devlin & Nasar (1989) used 20 "high" style and 20 "popular" style of residential building slides as a measurement tool, and asked 20 architects and 20 people from the general public as survey objects. The results showed that the architects and the general public's preference for these two styles of buildings are not the same. Architects tend to like high style residential buildings more, while the general public likes the popular style of residential buildings. Nasar (1989) used black and white photographs to show six residential buildings with different kind of architectural styles, and invited 220 people from the general public and 65 architects to do a preference measurement. The result found people from the general public have very little difference among themselves regarding to the residential style preference. However, architects' preferences are quite different from the general public.

- **Fuzzy**

Fuzzy theory is basically constructed on "fuzzy assembly". It's mainly used to express certain concepts that cannot be clearly defined, and there is a good use of result especially in performing the ambiguous aspect of human language. Fuzzy theory is mostly focus on the uncertainty of semantic expression. However, this uncertainty is different from the statistical random uncertainty since they are not the same in nature. Statistically, the random probability represents occurrence uncertainty. And that is determined by the probability measure function. On the other hand, the uncertainty in fuzzy theory is defined by the degree of uncertainty and is represented by the membership function. Fuzzy theory is to have characteristic function with values of 0 and 1 that expand into 0,1 continuous interval-valued function, and this function is called "membership function". The value of this function can express as the degree of elements  $\chi$  belongs to set A, and it also could express all the moderate values between the "yes" and "no". In short, this theory is using fuzzy assembly to replace traditional general collection. By using membership functions to handle ambiguous data, and then through a systematic process of fuzzy arithmetic, so that data can be quantified, and then converted into useable information.

## **RESEARCH METHODS**

- **Research Tool and Questionnaire Surveying**

This research is to explore the factors that may affect the creativity of works/ aesthetic performance by creating and work on interior design creativity/ aesthetic assessment questionnaire. This questionnaire-based research uses live interior designed color photographs as a study tool. The study first drew the characteristics or features (such as original, new, pleasing, smooth, and practical, etc.) of the project, and then collected 380 copies of various interior design images from foreign and domestic interior design professional publications and internet. Then, inviting seven experts classified and filtered the images based on space characteristics, and we obtain at least 70 images selected by four experts as a measuring tool. These 70 images were randomly scattered, numbered, and made into PowerPoint files for projecting purpose and measuring their creativity and beauty. The measurement of creative/ aesthetic level were using Likert's Five-Point Measurement rule. According to the rule, creativity is divided into: very creative, creative, ordinary, not very creative. The rating is from 1 to 5, with 5 being the "very creative". Similarly, aesthetic feeling could be rated from very

beautiful, a little beautiful, ordinary, not beautiful, and very not beautiful. The rating is also from 1 to 5, with 5 being the “very beautiful”.

The investigation invited six domestic universities' sophomore students whose major is interior design for the study. The survey is conducted in different classroom. The classes were randomly selected by the school teachers who agreed to participate in the study. When formally tested, the purpose and method of the survey was explained first, and then each image is automatically set to shown on the screen via projectors with interval of 7 seconds. The creative assessment came in first, and then came in the aesthetic feeling evaluation. Questionnaires are collected after surveying session is over and totally received 948 copies of questionnaires. After removing the invalid questionnaires, valid creative assessment came into 931 copies and aesthetic evaluation came into 938 copies.

### Data Analysis Methods

The data obtained from the 70- question survey was screened for the threshold value based on creativity and aesthetic feeling via fuzzy theory, in order to remove entries with no discernible capability. The calculation method is: the result of every question's minimum value plus maxima value and geometric mean, divided by 3, to get each question's triangular fuzzy numbers.

Next, by using the simple gravity method, the whole "minimal value of fuzzy numbers" + "maxima value of fuzzy numbers" + "geometric mean of the fuzzy number " divided by 3, we got the screening threshold value. Through this method of calculation, the screening threshold value of creativity assessment came into 3.039 and the aesthetic evaluation came into 3.020. After deleting these entries could not reach the threshold value, and then proceed principal component analysis to the questions that passed screening process. Finally we extracted factors with eigenvalues greater than 1 after the questions went through orthogonal axes by using the maxima variation method.

In order to find a better balance between a number of factors and the overall explainable amount of variation, we eliminated some questions by reviewing each question's factor loading shaft. That is, to eliminate the questions with factor loading of less than 0.5 and cross-factor loading of less than 0.4, as well as the questions with a single subject consisting only one factor. We than repeated this process several times until a better balance point was reached. Finally, expert meeting method was proceeded to do factors naming for creativity and assessment as well as interpretation and description for all the factors' psychological attributes and visual features, respectively. Psychological attribute refers to the overall feeling of space given in the photos, using adjectives to express, as described in the specific appearance.

## STUDY RESULTS

After screening the total of 70 questions by triangular fuzzy numbers; creativity assessment selected a total of 46 questions and deleted 24 questions. At the same time, aesthetics evaluation obtained 31 questions after screening and deleted 39 questions (for details, see Table 1).

**Table 1: Fuzzy Number Screening Results**

Creativity Assessment (n=931)						Aesthetics Assessment (n=938)					
Question Number	Max Value	Geometric Mean	Min Value	Fuzzy Number	Screening Result <sup>a</sup>	Question Number	Max Value	Geometric Mean	Min Value	Fuzzy Number	Screening Result <sup>b</sup>
C01	5	3.53	1	3.176	✓	A01	5	2.83	1	2.942	x
C02	5	3.14	1	3.046	✓	A02	5	2.87	1	2.955	x
C03	5	3.89	1	3.296	✓	A03	5	3.61	1	3.205	✓
C04	5	3.34	1	3.112	✓	A04	5	3.28	1	3.094	✓
C05	5	3.70	1	3.233	✓	A05	5	3.82	1	3.275	✓

Table 1: Contd.,

C06	5	2.84	1	2.945	x	A06	5	2.58	1	2.860	x
C07	5	3.74	1	3.247	✓	A07	5	3.61	1	3.203	✓
C08	5	2.65	1	2.883	x	A08	5	2.84	1	2.945	x
C09	5	2.70	1	2.899	x	A09	5	2.52	1	2.841	x
C10	5	3.73	1	3.242	✓	A10	5	3.83	1	3.276	✓
C11	5	3.51	1	3.170	✓	A11	5	2.83	1	2.944	x
C12	5	3.76	1	3.254	✓	A12	5	3.52	1	3.173	✓
C13	5	3.14	1	3.046	✓	A13	5	2.48	1	2.825	x
C14	5	2.99	1	2.998	x	A14	5	2.93	1	2.976	x
C15	5	3.03	1	3.011	x	A15	5	3.42	1	3.138	✓
C16	5	3.25	1	3.085	✓	A16	5	2.49	1	2.829	x
C17	5	2.74	1	2.912	x	A17	5	2.80	1	2.934	x
C18	5	3.40	1	3.133	✓	A18	5	2.61	1	2.870	x
C19	5	3.67	1	3.224	✓	A19	5	3.49	1	3.162	✓
C20	5	3.16	1	3.052	✓	A20	5	3.17	1	3.056	✓
C21	5	3.13	1	3.045	✓	A21	5	3.23	1	3.078	✓
C22	5	3.07	1	3.023	x	A22	5	3.31	1	3.102	✓
C23	5	3.15	1	3.051	✓	A23	5	2.74	1	2.914	x
C24	5	3.59	1	3.195	✓	A24	5	3.38	1	3.125	✓
C25	5	3.34	1	3.113	✓	A25	5	2.95	1	2.985	x
C26	5	3.05	1	3.017	x	A26	5	2.89	1	2.963	x
C27	5	3.37	1	3.122	✓	A27	5	3.22	1	3.072	✓
C28	5	3.69	1	3.231	✓	A28	5	2.97	1	2.991	x
C29	5	3.33	1	3.110	✓	A29	5	2.83	1	2.942	x
C30	5	2.79	1	2.931	x	A30	5	2.83	1	2.943	x
C31	5	2.57	1	2.856	x	A31	5	3.17	1	3.056	✓
C32	5	3.46	1	3.153	✓	A32	5	3.61	1	3.204	✓
C33	5	2.85	1	2.950	x	A33	5	2.90	1	2.967	x
C34	5	3.81	1	3.270	✓	A34	5	3.57	1	3.192	✓
C35	5	3.52	1	3.174	✓	A35	5	3.22	1	3.074	✓
C36	5	3.12	1	3.041	✓	A36	5	2.81	1	2.938	x
C37	5	3.48	1	3.161	✓	A37	5	3.12	1	3.041	✓
C38	5	2.74	1	2.912	x	A38	5	3.04	1	3.014	x
C39	5	3.43	1	3.145	✓	A39	5	3.19	1	3.063	✓
C40	5	3.22	1	3.074	✓	A40	5	3.26	1	3.087	✓
C41	5	2.99	1	2.995	x	A41	5	2.82	1	2.939	x
C42	5	3.42	1	3.141	✓	A42	5	2.82	1	2.942	x
C43	5	3.27	1	3.089	✓	A43	5	3.39	1	3.131	✓
C44	5	2.91	1	2.970	x	A44	5	2.64	1	2.879	x
C45	5	2.98	1	2.995	x	A45	5	3.35	1	3.117	✓
C46	5	3.70	1	3.233	✓	A46	5	2.88	1	2.960	x
C47	5	3.72	1	3.241	✓	A47	5	2.89	1	2.964	x
C48	5	3.56	1	3.185	✓	A48	5	2.87	1	2.956	x
C49	5	3.77	1	3.257	✓	A49	5	3.32	1	3.106	✓
C50	5	3.53	1	3.176	✓	A50	5	2.29	1	2.765	x
C51	5	3.32	1	3.107	✓	A51	5	2.84	1	2.947	x
C52	5	3.02	1	3.008	x	A52	5	2.46	1	2.819	x
C53	5	3.70	1	3.232	✓	A53	5	3.32	1	3.107	✓
C54	5	2.75	1	2.917	x	A54	5	3.24	1	3.081	✓
C55	5	3.04	1	3.013	x	A55	5	3.02	1	3.006	x
C56	5	3.48	1	3.160	✓	A56	5	3.33	1	3.111	x
C57	5	2.71	1	2.905	x	A57	5	2.48	1	2.828	x
C58	5	3.47	1	3.157	✓	A58	5	3.58	1	3.195	✓
C59	5	3.00	1	3.001	x	A59	5	2.75	1	2.916	x
C60	5	3.50	1	3.167	✓	A60	5	3.44	1	3.146	✓
C61	5	3.52	1	3.172	✓	A61	5	3.04	1	3.012	x
C62	5	3.29	1	3.096	✓	A62	5	3.16	1	3.054	✓
C63	5	3.21	1	3.071	✓	A63	5	2.80	1	2.933	x
C64	5	3.05	1	3.016	x	A64	5	3.65	1	3.218	✓
C65	5	2.24	1	2.746	x	A65	5	2.77	1	2.924	x
C66	5	3.14	1	3.046	✓	A66	5	3.53	1	3.175	✓
C67	5	3.33	1	3.110	✓	A67	5	2.94	1	2.978	x
C68	5	2.35	1	2.784	x	A68	5	2.78	1	2.928	x
C69	5	3.38	1	3.126	✓	A69	5	3.70	1	3.233	✓
C70	5	2.25	1	2.750	x	A70	5	2.89	1	2.965	x
<sup>a</sup> screening value : (total minimum fuzzy number 2.746+ total maximum fuzzy number 3.296+ geometric mean of all the fuzzy numbers 3.075) / 3 = 3.039						<sup>b</sup> screening value : (total minimum fuzzy number 2.765+ total maximum fuzzy number 3.276+ geometric mean of all the fuzzy numbers 3.020) / 3 = 3.020					

Next, we proceeded to the exploratory factor analysis and deletion for the questions filtered by the triangular fuzzy number screening, in order to find a better balance between the number of factors and the overall amount of variation. After three rounds of evaluation on the creativity assessment, 17 questions were deleted and 19 questions remain, and we come to six factors with a cumulative explainable variance of 54.475% (see Table 2 and Table 3). In the aesthetic assessment part, after 2 rounds of same process and after deleting 11 questions and hold one 20 questions, we obtain five factors with a cumulative explainable variance of 52.899% (see Table 4 and Table 5).

**Table 2: The Creative Assessment's Deletion Process**

Total Questions	Question Deletion	Cronbach's $\alpha$	Factor #	KMO	Bartlett Spherical Testing's Approximation to the Cards Distribution	df	p	Cumulative Explainable Variance%
46	-	.918	11	.926	10958.881	1035	.000	51.959
26	10	.858	7	.882	4668.772	325	.000	50.730
20	6	.817	6	.854	3094.690	190	.000	52.493
19	1	.814	6	.853	2992.495	171	.000	54.475

**Table 3: Exploratory Factor Analysis Summary for the Creative Assessment**

Image #	Mean*	Extract Factor and Loading					
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
C11	3.69	.683			.111	.116	
C27	3.52	.627		.309	.145		
C25	3.5	.603		.157	.163	.179	
C24	3.71	.574	.167	.305			.126
C16	3.46		.739			.165	
C23	3.33		.671	.251	.203		
C21	3.28		.526	.400	.206		.215
C13	3.33	.305	.502		-.120	.132	.179
C66	3.31			.680	.169	.145	
C32	3.62	.288	.193	.597			
C69	3.53			.591	.240		.278
C63	3.36	.170	.273		.611		-.160
C56	3.61	.128	-.127	.147	.606	.190	.203
C40	3.36			.158	.597		.224
C51	3.48	.463	.145		.539		
C46	3.85	.132	.158			.825	
C47	3.86	.162		.121	.155	.808	
C05	3.81	.133		.118	.127		.790
C07	3.86		.170				.747
Initial Eigenvalues		4.43	1.73	1.33	1.1	1.05	1.02
Mean*		3.61	3.35	3.49	3.45	3.86	3.84
Explainable Variance %		10.97	9.44	9.1	8.99	8.02	7.95
Cumulative Explainable Variance %		10.97	20.41	29.51	38.51	46.53	54.48

\* Mean Range from 1 to 5

**Table 4: Relevant Values of Deleting Process for Aesthetic Assessment**

Question #	Deletion #	Cronbach's $\alpha$	Factor #	KMO	Bartlett Spherical Testing's Approximation to the Cards Distribution	df	p	Cumulative Explainable Variance%
31	-	.889	7	.905	7228.121	465	.000	50.892
22	9	.848	5	.870	4586.254	231	.000	50.005
20	2	.840	5	.865	4172.410	190	.000	52.899




**Table 5: Exploratory Factor Analysis Summary for the Aesthetic Assessment**

Image #	Mean *	Extract Factor and Loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
A39	3.37	.719		.266		
A32	3.74	.707	.100		.149	
A22	3.45	.620	.171			.287
A45	3.48	.604	.161	.112	.186	
A15	3.56	.571	.141		.235	.122
A62	3.32	.212	.614	.129	.324	
A49	3.51	.330	.608			
A35	3.39		.595	.293		.206
A07	3.74		.574	.246		.191
A19	3.63	.384	.546	.131	.127	
A12	3.70		.189	.759		.102
A37	3.35	.239		.698	.124	
A04	3.43			.652	.142	.247
A58	3.73		.249	.526	.389	
A66	3.68	.107			.759	
A64	3.78	.221	.235		.679	
A31	3.36	.184		.195	.526	.444
A24	3.54		.143	.340		.641
A43	3.54	.391			.120	.611
A05	3.94		.521		.137	.558
Initial Eigenvalues		5.02	1.88	1.36	1.24	1.08
Mean*		3.52	3.52	3.55	3.61	3.67
Explainable Variance %		13.53	11.47	11.18	8.87	7.84
Cumulative Explainable Variance%		13.53	25	36.18	45.06	52.9

\*Mean Range from 1 to 5

Finally, we are here to name each of the factors and interpret/ describe their psychological attributes and visual features. The details are shown in Table 6 and Table 7.






Table 6: Different Creativity Factor's Representative Image and Their Properties

	Representing Image & Its #		Factor's Name, Attributes and Characteristics
Factor 1		C11	Factor name: modern ingenuity Psychological attributes: ingenuity, personalized, modern Visual feature: using the purple decorative wall as background, to bring out the shape of cloth coated white staircase connecting the upper and lower two beds
Factor 2		C16	Factors name: colorful lively Psychological attributes: colorful, enthusiastic, lively Visual feature: decorative flowers made from clothes hanging from the ceiling, is embraced with the colorful and yet simple styling tables and chairs
Factor 3		C66	Factors name: smooth tension Psychological attributes: smooth, shining, tension extension Visual features: vertical wood line shape background, heightening the fine lighting, creating an elegant dining environment
Factor 4		C63	Factors name: modern luxury Psychological attributes: modern, luxurious, beautiful Visual features: beautiful crimson tone ceilings, exposed illuminating light engraving its styling change
Factor 5		C46	Factors name: mysterious dream Psychological attributes: mystery, fantasy, exotic Visual feature: using dark tones as the background to set off the blue lighting silhouette face shape, and contrast with the ground color
Factor 6		C05	Factors name: pure rhythm Psychological attributes: simplicity, rhythm, elegant Visual features: repetition of curve shape extending from wall to ceiling, with indirect lighting to highlight its shape and light but elegant color tone

\* Representative picture has the highest factor loadings among all factors



Table 7: Different Aesthetic Factor's Representative Image and Their Properties

	Representing Image & Its #	Factor's Name, Attributes and Characteristics
Factor 1		A39 Factors name: warm texture Psychological attributes: woody, sensual, warm Visual features: natural woody texture, orderly and emotional styling or stacking, heightening the warm lighting
Factor 2		A62 Factors name: modern classic Psychological attributes: modern, with a sense of design and taste Visual feature: repeating braided line with a modern design sense made up the ceiling, with clever seating
Factor 3		A12 Factors name: contemporary psychedelic Psychological attributes: smooth, psychedelic, contemporary Visual features: modern materials and curving shape, match fantastic lighting, showing the flowing curvy and a sense of infinite tension
Factor 4		A66 Factors Name: quiet elegance Psychological attributes: quiet, elegant and comfortable Visual characteristics: natural wood lines, hanging lighting, suitable furniture decorations, overall constituting a close integration
Factor 5		A24 Factors name: smooth and elegant Psychological attributes: smooth, elegant, Japanese-style Visual features: geometric lines form, pure and smooth texture and color, appropriate embellish decorations

\* Representative picture has the highest factor loadings among all factors

## CONCLUSIONS

The results above will be used as further elaboration and fundamental for the creative works of interior design / basic aesthetic evaluation indicators and scales.

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